APPENDIX A

MARKET DEFINITION,
DEMAND ESTIMATION, AND DATA

A.1 PRODUCT/MARKET CROSS-REFERENCE METHOD

Data on coating prices, quantities, average VOC contents, and VOC content limits are necessary to estimate the effect of VOC content limits on architectural coatings products. Price and quantity data were taken from the 1991 Current Industrial Reports: Paint and Allied Products.[1] The Architectural and Industrial Maintenance Surface Coatings Survey (the survey)[2] provided the sales-weighted average VOC emissions, which represent VOC content. VOC content limits were from the TOS developed by EPA.

Census data are organized according to product codes, which define product categories; however, these Census product categories differ from the product categories in the survey. Furthermore, the TOS (see Table 2-1) gives VOC content limits for product categories that differ slightly from those categories for which data are provided in the survey. Data from all three sources are necessary to conduct the economic impact analysis. Therefore, a fourth product categorization was constructed, which is called market segments, that aggregates the categories so that data may be used from all three sources to provide the necessary level of resolution for market analysis. Table A-1 illustrates the individual product categories represented by each data source and how they map into the market segments used in the analysis.[3,4]

The mapping in Table A-1 proceeds from the most aggregated category to the least aggregated category. In some cases, however, the survey provides more detail than the TOS.

TABLE A-1.   PRODUCT/MARKET CROSS-REFERENCE

Market Segment	Current Industrial Report Census Category	Census Product Code	VOC Emission Inventory Survey Category	Table of Standards Proposed Regulation Limits Category
Exterior solventborne	Exterior solvent paints and tinting bases, including barn and roof paints	2851112	Roof coatings--solventborne	Roof coatings[a]
	Exterior solvent enamels and tint, including ex.-in floor enamels	2851115	Flat, exterior, solventborne	Flat, exterior[a]
	Other exterior solvent coatings, including bituminous paints	2851139	High performance arch. coatings--solvent	High performance, floor coatings[a]
			Bituminous coatings--solvent	Bituminous coatings and mastics[a]
				High performance, rust preventive[a]
				High performance, concrete protective[a]
			Nonflat, exterior--solvent	Nonflat, exterior[a]
Exterior waterborne	Exterior water paints and tinting bases, including barn and roof paints	2851141	Flat, exterior, waterborne	Flat, exterior[a]
	Exterior water exterior--interior deck and floor enamels	2851142	Roof coatings--waterborne	Roof coatings[a]
			Nonflat, exterior--waterborne	Nonflat, exterior[a]
	Other exterior water coatings	2851155	High performance arch. coatings--water	High performance, floor coatings[a]
			Bituminous coatings--water	Bituminous coatings and mastics[a]
				High performance, rust preventive[a]
				High performance, concrete protective[a]
Interior solventborne	Interior flat solvent wall paints and tinting bases	2851163	Flat, interior--solventborne	Flat, interior[a]
	Interior solvent gloss and quick dry enamels and other solvent paints and tint	2851165	Nonflat, interior--solventborne	Nonflat, interior[a]
	Interior semigloss, eggshell, satin solvent paints and tinting bases	2851169	Quick dry enamels	Quick dry enamels
Interior waterborne	Interior flat water paints and tinting bases	2851181	Flat, interior--waterborne	Flat, interior[a]
	Interior semigloss, eggshell, satin and other water paints and tints	2851183	Nonflat, interior--waterborne	Nonflat, interior[a]
Solventborne primers and undercoaters group	Exterior solvent undercoaters and primers	2851125	Primers, solventborne	Primers and undercoaters[a]
	Interior solvent undercoaters and primers	2851171	Undercoaters, solventborne	
			Q.D. primers, sealers, undercoaters--solvent	Quick dry primers, sealers, undercoaters[a]

See notes at end of table.

(continued)

TABLE A-1. PRODUCT/MARKET CROSS-REFERENCE (CONTINUED)

Market Segment	Current Industrial Report Census Category	Census Product Code	VOC Emission Inventory Survey Category	Table of Standards Regulation Limits C…
Waterborne primers and undercoaters group	Exterior water undercoaters and primers Interior water undercoaters and primers	2851144 2851186	Primers, waterborne Undercoaters, waterborne Q.D. primers, sealers, undercoaters--water	Primers and undercoaters Quick dry primers, sealers, undercoaters[a]
Solventborne clear coating, sealer, and stain	Exterior solvent clear finishes and sealers Interior solvent clear finishes and sealers Exterior solvent stains Interior solvent stains	2851135 2851175 1851137 1851177	Sealers, solventborne Shellacs Waterproofing sealers w/pigment, solvent Waterproofing sealers-- clear, solvent Varnishes, solventborne Stains, opaque, solventborne Stains, semitransparent, solventborne	Sealers[a] Sealers--shellacs, clear Sealers--shellacs, opaque Waterproofing sealers, opaque[a] Waterproofing sealers, c… Varnishes[a] Stains, opaque[a] Stains, clear and semitransparent[a]
Waterborne clear coatings and stains group	Exterior water stains and sealers Other interior water coatings, stains, and sealers	2851149 2851188	Stains, opaque, waterborne Sealers, waterborne Stains, semitransparent, waterborne Waterproofing sealers w/pigment, water Waterproofing sealers-- clear, water Varnishes, waterborne	Stains, opaque[a] Sealers[a] Stains, clear, and semitransparent[a] Waterproofing sealers, opaque[a] Waterproofing sealers, c… Varnishes[a] Stains, low solids
Lacquers	Architectural lacquers	2851193	Lacquers	Lacquers
Wood preservatives group	Other miscellaneous allied paint products, including brush cleaners, nonpressure wood preservatives, putty, and glazing compounds, etc.	2851598	Wood preservatives, below-ground Clear wood preservatives Semitransparent wood preservatives Wood preservatives, opaque	Wood preservatives, below-ground Wood preservatives, clear… semitransparent Wood preservatives, opaqu…
Traffic marking paints	Traffic marking paints	2851311	Traffic paints	Traffic marking paints

See notes at end of table.

TABLE A-1. PRODUCT/MARKET CROSS-REFERENCE (CONTINUED)

Market Segment	Current Industrial Report Census Category	Census Product Code	VOC Emission Inventory Survey Category	Table of Standards Regulation Limits Co...
Special purpose group	Special purpose coatings, n.s.k.	2851300	Dry fog coatings	Dry fog coatings
			Metallic pigmented coatings	Metallic pigmented coati...
				Antifouling coatings
			Antigraffiti coatings	Antigraffiti coatings
				Bond breakers
				Chalkboard resurfacers
			Concrete curing compounds	Concrete curing compound...
			Form release compounds	Form release compounds
			Graphic arts coatings	Graphic arts coatings
				Impacted immersion coati...
			Multicolor coatings	Multicolor coatings
			Pretreatment wash primers	Pretreatment wash primer...
			Swimming pool coatings	Swimming pool coatings
				Flow coatings
Industrial maintenance group	Interior industrial new construction and maintenance paints	2851301		Antenna coatings
	Exterior industrial new construction and maintenance paints	2851305		Extreme high durability coatings
			Fire-retardant/resistive coatings	Fire-retardant/resistive coatings
			High temperature coatings	High temperature coatings
			Magnesite cement coatings	Magnesite cement coatings
			Mastic texture coatings	Mastic texture coatings
				Nonferrous ornamental me... lacquer and surface pro...
				Nuclear power plant coat...
				Repair and maintenance thermoplastic
			Sanding sealers	Sanding sealers
				Thermoplastic rubber coa... and mastics
			Industrial maintenance coatings	Industrial maintenance coatings
			Appurtenances	Heat reactive coatings

a In the TOS, only one limit for both solvent and waterbornes is given; for presentation the product is listed under both.

Sources: U.S. Department of Commerce. Current Industrial Reports: Paint and Allied Products, 1991. Washington, D.C. Government Printing Office. 1992.
Industry Insights. Architectural and Industrial Maintenance Surface Coatings VOC Emissions Inventory Survey. Prepared for the National Paint and Coating
cooperation with the AIM Regulatory Negotiation Industry Caucus. Final draft report. 1993.

Where possible, the market segments were paired as solvent borne and waterborne coating categories. Separate market segments could not be created for flat and nonflat coatings in the interior and exterior segments because the Census data do not differentiate between exterior flats and nonflats.

The necessary data were developed for each of the 13 market segments using the mapping scheme presented in Table A-1. Data for individual Census product codes were summed where necessary to compute prices and quantities.

A.2 ESTIMATING DEMAND ELASTICITIES FOR COATINGS

To perform the market analysis, own- and cross-price elasticities of demand were estimated for four broad coating categories: exterior solventborne and interior solventborne and their two respective substitutes, exterior waterborne and interior waterborne. The variables used in estimation are domestic consumption quantity; real value of domestic consumption; real consumption price; national income; a housing variable; and the real price of alkyd resins, acrylic resins, and titanium dioxide. Complete data for these variables were collected for the years 1981 through 1991. Justification of these variables and their data sources is given below.

A.2.1   Estimation Procedure and Results

Econometric estimation of the interrelated demand system for interior solventborne, interior waterborne, exterior solventborne, and exterior waterborne architectural coatings generated estimates of own-price demand elasticities for each of the four groups and cross-price demand elasticities between the solventborne and waterborne segments of each interior (exterior) pair.

The quantity demanded of a commodity is a function of its price, the price of any substitutes and other factors, such as income, that affect aggregate demand. Estimating the demand function, however, is more complicated than just running regressions of observed market quantities on observed market prices and other demand variables. One must account for the fact that the observed prices and quantities are equilibrium values, which are simultaneously determined by both demand and supply factors.

Variables that are determined within a system (such as prices and quantities in a market equilibrium system) are endogenous to that system, whereas those variables determined outside of the particular system (e.g., income, housing activity) are termed exogenous. In simultaneous equations models, endogenous variables are correlated with the error terms through solution of the system. As a result of the interdependence of the endogenous variables and the error terms, the application of standard regression techniques is modified to estimate the effect of an endogenous right-hand side variable (i.e., equilibrium price) on the endogenous left-hand dependent variable (equilibrium quantity). In general, ordinary least squares estimation of the individual demand equations leads to biased and inconsistent parameter estimates when a regressor is endogenous.

Endogeneity bias is corrected by applying the two-stage least squares (2SLS) regression procedure for each estimated equation (see, for example, Pindyck and Rubinfield[5]). In the first stage of the 2SLS method, the price observations were regressed against all exogenous demand and supply variables in the system. This regression produced fitted (predicted) values for the price variables that are, by definition, highly correlated with the true endogenous variable (the observed equilibrium price) and uncorrelated with the error term. In

the second stage, these fitted values were employed as observations of the right-hand side price variables in the demand equations. This procedure can also be used to estimate the underlying structural supply equations; however, because of the poor performance of various specifications in the supply estimations, only demand estimates are reported here.

The 2SLS procedure was used to estimate the four demand functions. Both linear and double-log regressions were estimated. The double-log specifications are presented here because of slightly better statistical fit and because the parameter estimates are directly interpretable as point elasticities.

For the two exterior categories, housing completions are included as an exogenous demand determinant. Exogenous supply factors incorporated into the first-stage regressions include the prices of various raw material inputs and a price index for substitute outputs, which captures the effect of non-exterior coatings prices on the supply of exterior coatings. For the two interior categories, U.S. domestic GNP is included as a proxy for the exogenous effect of aggregate income on the demand for interior coatings. Exogenous supply factors incorporated into the first-stage regressions also include the prices of various raw material inputs and a price index for substitute outputs, which in this case captures the effect of noninterior coatings prices on the supply of interior coatings. The results of the demand estimations are shown in Table A-2.

Unfortunately, sufficient data to estimate the demand parameters for the other market segments were unavailable. For the other two solvent/water-paired segments—clear coatings and primers/undercoaters—the mean of the respective own- and

TABLE A-2. DEMAND CURVE ESTIMATES

Variable	Adjustable R^2	F-Value	Elasticity Estimate	t-statistic
Exterior solventborne demand	0.94	50.52		
Log-housing completions			0.17	3.30
Log exterior solventborne price			-1.43	-1.89
Log exterior waterborne price			0.20	0.36
Exterior waterborne demand	0.92	39.36		
Log-housing completions			-0.05	-0.62
Log exterior solventborne price			0.51	0.42
Log exterior waterborne price			-1.89	-2.17
Interior solventborne demand	0.69	8.49		
Log GNP			1.01	1.67
Log interior solventborne price			-1.50	-1.74
Log interior waterborne price			1.43	1.28
Interior waterborne demand	0.99	588.90		
Log GNP			1.00	5.07
Log interior solventborne price			0.36	1.28
Log interior waterborne price			-1.39	-3.80

cross-price elasticities from the interior and exterior estimation process were used as proxies for the elasticities. The other five segments—special purpose, industrial maintenance group, traffic marking paints, lacquers, and wood preservatives—are specialty groups whose demand is assumed to be fairly inelastic and not dependent on prices in the other segments. Therefore, a value of -0.5 for the own-price demand elasticity and zero for all cross-price elasticities were assigned to each of these categories. Table A-3 provides the matrix of own- and cross-price elasticities for all 13 market segments.

A.2.2   Data Used in Demand Estimation

Domestic consumption quantities and values were calculated using data from U.S. Department of Commerce publications Current Industrial Reports: Paint and Allied Products[6,7,8,9,10,11,12,13,14] and U.S. Exports Schedule B Commodity by Country.[15,16,17,18,19,20,21,22] Domestic quantity and value of shipments figures were used, which include exports. Exports were then subtracted to estimate domestic consumption (architectural coatings imports are negligible and are not included in the consumption variable). Consumer price indexes from the U.S. Department of Labor's Handbook of Labor Statistics[23] and the U.S. Department of Commerce's Survey of Current Business[24,25,26] are used to adjust the current figures to real values. Real consumption price was imputed for each product by dividing real value of domestic consumption by the quantity of domestic consumption.

TABLE A-3. DEMAND ELASTICITY MATRIX FOR ARCHITECTURAL COATINGS MARKET SEGMENTS

Percentage
Change in
Quantity Demand
of Product

With Respect to Percentage Change in Price of Product

Market segment	1	2	3	4	5	6	7	8	9	10	11	12	13
1	-1.43	0.20	0	0	0	0	0	0	0	0	0	0	0
2	0.51	-1.89	0	0	0	0	0	0	0	0	0	0	0
3	0	0	-1.50	1.43	0	0	0	0	0	0	0	0	0
4	0	0	0.36	-1.39	0	0	0	0	0	0	0	0	0
5	0	0	0	0	-1.47	0.82	0	0	0	0	0	0	0
6	0	0	0	0	0.44	-1.64	0	0	0	0	0	0	0
7	0	0	0	0	0	0	-1.47	0.82	0	0	0	0	0
8	0	0	0	0	0	0	0.44	-1.64	0	0	0	0	0
9	0	0	0	0	0	0	0	0	-0.50	0	0	0	0
10	0	0	0	0	0	0	0	0	0	-0.50	0	0	0
11	0	0	0	0	0	0	0	0	0	0	-0.50	60	0
12	0	0	0	0	0	0	0	0	0	0	0	-0.50	0
13	0	0	0	0	0	0	0	0	0	0	0	0	-0.50

The GNP in constant 1987 dollars from 1981 through 1991 was used as an aggregate income measure.[a,27,28,29] Housing completions for 1981 through 1991 were obtained from the U.S. Department of Commerce's Current Construction Reports.[30] Prices for alkyd and acrylic resins are obtained from the U.S. International Trade Commission publication Synthetic Organic Chemicals, U.S. Production and Sales.[31,32,33,34,35,36,37,38,39,40] Prices for titanium dioxide were imputed using quantity and value of shipment data for U.S. production from the Current Industrial Reports, Inorganic Chemicals.[41] Real prices for these raw materials were calculated by deflating normal values using CPIs. Alkyd and acrylic resins were used to represent raw materials for the nonvolatile vehicle portion of the coatings, which are found mainly in solventborne and waterborne coatings, respectively. Titanium dioxide was used to represent a raw material in the pigment portion of the coating, which is found in both types of coatings. A Laspeyres price index was constructed to incorporate the price of substitute outputs as a supply-side effect in the first stage regressions of the 2SLS procedure. Let the price and quantity of commodity n in period t be p_n^t and q_n^t,

respectively for $n = 1, \ldots, N$ and $t = 0, 1, \ldots, T$. Then the Laspeyres price index of the N commodities for period t (relative to the base period 0) is defined as

$$P_L \equiv \sum_{N=1}^{N} p_n^t q_n^0 \;\Bigg|\; \sum_{N=1}^{N} p_n^0 q_n^0 \, . \tag{A-1}$$

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[a]All constant values were converted to 1982-1984 dollars for the analysis to be consistent with the consumer price index (CPI), which has 1982-1984 as a base.

Real domestic prices and quantities of nonexterior coatings were used to construct the price index for the exterior coatings equations and real domestic prices, and quantities of noninterior coatings were used to construct the index for the interior coatings equations. Each index is computed for the years 1981 through 1991, with 1981 serving as the base year.

A.3 EVALUATION OF DATA QUALITY

The Current Industrial Report series is generally considered a reliable source for quantities and values of products shipped. Monthly and annual data were estimated from a sample designed to measure activities of the entire paints and allied products industries. Each annual report provides data for 2 years, and figures from the 1991 report were used for the coatings analyses. In addition to the four representative coatings products, the architectural coatings Census category includes two other products: architectural lacquers and architectural coatings, not elsewhere classified. These categories were not included in the estimates because of insufficient data. However, in 1991, these two product categories combined represented only 1.3 percent of the total value of shipments for the architectural coatings market.[42]   Statistics reported in the Current Industrial Reports at the seven-digit SIC product level are based on Annual Surveys of Manufactures and represent about 95 percent of total shipments in the paint industry (SIC 2851).[43]
 To produce estimates for the entire industry, the Census Bureau inflates the quantity and value figures reported in the annual survey by a factor based on data reported by all

establishments in the 1987 Census of Manufactures.[b] The
inflation factors for architectural coating product categories
are as follows: 1987 through 1991, 1.00; 1982 through 1986,
1.004; and for 1981, 1.04.[c] Quantity and value figures for
the four product categories used in the demand estimation are
inflated using these factors. Prior to 1981, data were not
collected at the more specific seven-digit SIC level. Using
the longer time series would provide more data points but
would also preclude analysis of the individual product
categories, and representativeness would be lost.

The export data used are the best publicly available;
however, combining export and domestic data to estimate
domestic consumption poses some problems. The classification
systems used to gather both types of data are different, and
the corresponding product categories used cannot always be
compared. For example, data from the U.S. Department of
Commerce publication U.S. Imports for Consumption and General
Imports, TSUSA Commodity by Country of Origin were not used
because the imported commodity classifications had no
comparable domestic output classification. Exclusion of
imports from the estimate of domestic consumption does not
pose a problem because in 1991 the value of imports for
architectural, OEM, and special purpose coatings (SIC 28511,
28512, 28513) combined represented less than 0.9 percent of
the total domestic value of shipments.[44] Data from U.S.
Exports Schedule B Commodity by Country were available for
1981 through 1991, and the export categories correspond well

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[b]The inflation factor for 1981 is based on 1977 Census relationships
and for 1982 through 1986 on 1982 Census relationships.

[c]The 1991 quantities and values used in the model (values to impute
price) also include products in the special purpose and miscellaneous
allied paint products categories. The special purpose inflator for 1991 is
1.06, and the miscellaneous inflator in 1991 is 1.18.

with the four domestic product categories except for 1989 through 1991.[45,46,47,48,49,50,51,52] In 1989, the export codes and categories changed and are no longer compatible with the domestic categories. In addition, quantities are reported in kilograms rather than gallons, as they were in previous years. For these reasons, export data were not used to adjust domestic consumption after 1988. The GNP data typically represent income for the entire nation including income generated from American businesses located overseas. The current price data for the paint products and raw materials should be considered reliable, though their accuracy may be affected by the exclusion of imports for the coatings products and of exports and imports for the raw materials prices. CPIs for all urban consumers with a base of 1982 through 1984 were used in calculating real prices.

The raw material prices used are representative of the entire U.S. and export market for these products, rather than just the U.S. supply to the paints and coatings industry. The alkyd resins were used in this estimation to represent an input found only in solventborne coatings and acrylic resins to represent an input found only in waterborne coatings. However, some acrylic resin materials are used in some solventborne coatings and alkyd resins are used as modifiers in waterbornes. Exports and imports were not considered when computing raw material supply prices because foreign trade data were not available for alkyd and acrylic resins. In 1991, exports of titanium dioxide represented 17.9 percent of the total domestic value shipped and imports were 10.9 percent.[53]

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